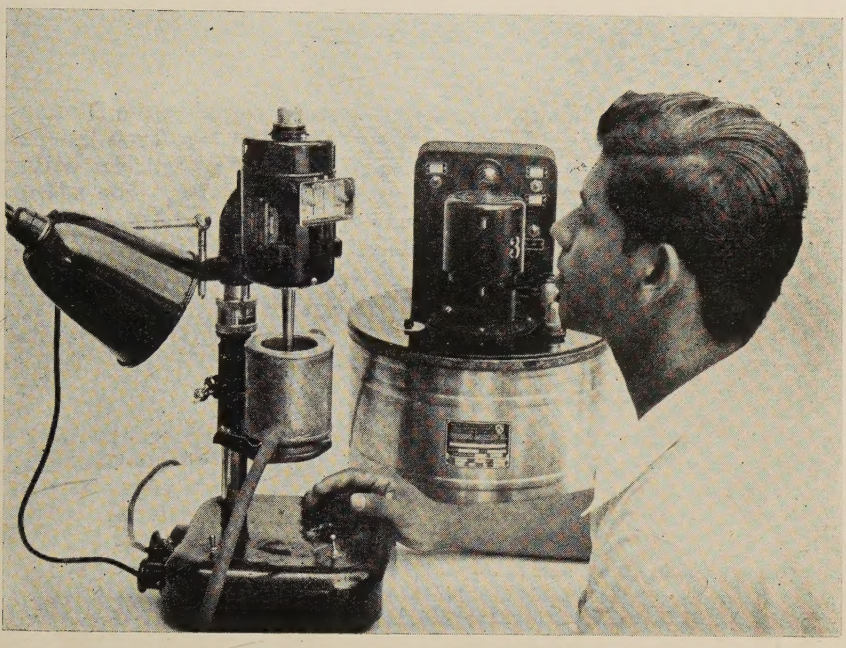
PLANTERS' BULLETIN

OF THE RUBBER RESEARCH INSTITUTE OF MALAYA



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R R I

LOCATION. The Institute's Laboratories and Offices are at the third mile, Ampang Road, Kuala Lumpur.

CORRESPONDENCE. All LETTERS must be addressed to the Director. Rubber Research Institute of Malaya, Post Office Box 150, Kuala Lumpur. Special inquiries may be marked for the attention of a particular officer, if so desired (See Staff List in Bulletin No. 1, page 24). The address for TELEGRAMS is Searching, Kuala Lumpur. TELEPHONE: Kuala Lumpur 3351/2/3. PARCELS occasionally arrive without any indication of their origin. It is requested that senders will write their names and addresses clearly on the outside of all packages, and also advise the Institute by letter or telegram of their despatch. This is especially important for perishables, such as latex samples and plant specimens.

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ADVICE. Inquiries are invited from rubber producers in the Federation of Malaya, the Colonies of Singapore and North Borneo, and the territories of Sarawak, Brunei and Nigeria, who may require more detailed information applicable to their own special problems. INTERVIEWS should be arranged by letter or telephone, as members of the senior research and advisory staff are frequently absent on visits to plantations. The Institute is open from 8 AM to 1 PM and 2 PM to 4 PM on Mondays to Fridays, and from 8 AM to 12.30 PM on Saturdays.

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PUBLICATIONS. A list of 'Publications of the R.R.I.' is available on request. Subscription to Planters' Bulletin may be made by depositing $10 with us.

PLANTERS' BULLETIN

OF THE RUBBER RESEARCH INSTITUTE OF MALAYA

Kuala Lumpur March 1954 Number 11

Can Research Save Natural Rubber?

It is our impression that people in Malaya do not realise the seriousness of the present situation concerning natural *versus* synthetic rubber. During the past five years there has been a steady decline in the use of natural rubber in the U.S.A. and a concomitant increase in the consumption of synthetic. This is apparent to all who care to take a look at consumption statistics. But the story doesn't stop there. This vast change in the quantities of natural and synthetic rubber used by the American manufacturing industry follows upon intensive research during the war years. Research was not dropped when GR-S had become well established; it still continues, and it has had as its objective improvement in the quality of synthetic rubbers and the development of materials for specific purposes. Perhaps no one is convinced that GR-S is a better all round material than natural rubber, but there has been a steady increase in special purpose rubbers, oil resistant rubbers like the thiokols, heat resistant materials as for instance the silicones, leather resembling materials such as Neolite, and many more. We in Malaya have perhaps not taken these developments too seriously; they did not represent a vast consumption of rubber anyway. We may have felt a certain security in the fact that the major part of the world's natural rubber was used for tyres; in spite of many claims by the producers of synthetic rubber there was no striking evidence of real superiority of a synthetic over the natural product. It may be that this situation has now changed.

The development of two series of synthetic copolymers, one using isocyanates and the other epoxy compounds, has now resulted in materials for which the claim of superlative excellence may be justified. It has been stated that a tyre tread, based on one of these materials and one eighth of an inch thick, will outlast the life of an average car; laboratory tests show it to posses truly remarkable properties. These materials are versatile in their application. Not only can they be used for tyre treads, but a German product at present commercially obtainable produces a foam 'rubber' mattress, light and delightful in quality, and simple in the extreme to manufacture. Admittedly these new products are expensive, they are in short supply, they are difficult to process. But give the manufacturers five years, and it is our guess that the picture will be very different. Already scientific papers are appearing in the journals indicating new methods to make processing simpler.

Taking it by and large, the present situation and the outlook are not at all bright for the natural rubber industry. From the purely technological point of view, there is little hope of large quantities of natural rubber being used in the future unless some trenchant measures are undertaken to improve quality beyond all recognition. Fortunately the

technological point of view is not the only important factor: availability of materials alternative to natural rubber and comparative costs will both play a big part in moulding the future.

It is not so much that one fears natural rubber will no longer be used, but that owing to the more desirable properties of synthetic materials, natural will be playing the part of Cinderella. Manufacturers will then use natural rubber because they cannot get enough synthetic and the price they will pay is not likely to be high. Let us quote from the Goodyear Lecture of 1953, given by Mr John T. Blake in the autumn of that year:

> It would take a fairly large price differential in favour of natural rubber for us to return to its use. Even then, we would do this with great reluctance because we have no wish to manufacture inferior products.....We must improve the quality of synthetics for reasons of national security so that they are the preferred material for all purposes.

The present eminence of synthetic rubber has been achieved by research. Its further improvement will be achieved by research. What research has done for synthetic materials, it can do for natural rubber. Research, however, costs money and relative achievements on natural and synthetic rubbers are foreshadowed by the amounts spent. Thus in 1952, $21 million (Malayan) were spent on GR-S and butyl research in the U.S.A. (production *ca* 750,000 tons) whereas on natural rubber considerably less than $3 million (Malayan) were spent on research in Malaya and the U.K. (production *ca* 600,000 tons).

In its Editorial for October 1953 the *India Rubber World* quotes a research director as stating: 'The best guess that I can make is that after plant disposal the rubber industry will spend between G$13 million' (=$39 million Malayan) 'and G$15 million' (=$45 million Malayan) 'per year on synthetic rubber research.'

A pertinent question to ask is what can the research man do for us now. Is it out of the question to modify natural rubber to produce an outstandingly better product? Obviously there is no simple answer to this question — no one knows at present. But judging from what is now being achieved in the field of emulsion polymerisation, it does not appear a wild dream to think of producing from natural rubber a copolymer with other suitable monomers, which would possess the outstanding properties needed today. This would probably mean replacing the present system of sulphur vulcanisation which has been in vogue over a hundred years; the vulcanisation or cross linking would be effected by the additional monomer. There are numerous possibilities in this direction and some are already being investigated by our sister research organisation in the U.K. as well as in Malaya. It is not easy to decide the weight and priority that should be given to investigations of this sort. On the face of it, an all out effort would appear to be called for. But it would be a drastic step to curtail most of the research activity on the product as it is used at the moment, and gamble on producing a 'winner' by these novel methods.

The answer is a simple one — increase expenditure on research. The synthetic rubber industry has come into being with extraordinary rapidity by expending large sums on research, and by stepping on the shoulders of the industry built up by the natural rubber producers over

half a century. Perhaps, in return, the natural rubber protoganist may be excused if he looks rather closely at the techniques of synthetic rubber production, with a view to abstracting information which will help to keep natural rubber in the forefront. The natural rubber molecule would probably prove to be adaptable, and one might venture to expect products not only resembling rubber; the possibility of materials suitable for other industrial applications should be kept in mind.

Apart from this possibility of effecting a marked change in the technique of utilising natural rubber, are there other steps which should be taken at the moment to ensure a continued existence for what otherwise might become a declining industry?

The factor of cost is perhaps an obvious one to tackle. Although low cost will not hold a market indefinitely in competition with technically superior materials, it will at least extend its hold on an existing market.

It is obvious to everyone that to reduce cost of production would be a step in the right direction, but how can it be done? One of the most costly items in producing natural rubber is harvesting the crop. Unfortunately no real progress has been made in reducing the labour involved in the mechanics of tapping and collecting nor is it likely that any advance will be made in the future. On the other hand, substantial achievements in reducing cost have been made possible by the breeding of high yielding clones. Further progress may be expected in this direction but must, by its nature, be slow. Reduction in costs of preparation are still possible, but they probably entail a major change in methods of production. One often hears the criticism that the rubber producing industry is still employing the methods used 50 years ago, and that a much greater degree of mechanisation could and should be introduced. By greater mechanisation a cheaper and a more uniform rubber could undoubtedly be produced. Development work in this field has been proceeeding in several countries during recent years and a number of pilot plant processes have been devised. None appears to be wholly satisfactory and at present we are studying the mechanisms of latex coagulation and of the drying of coagulum, to obtain basic data for the design of an efficient machine for converting latex into dry rubber. Greater emphasis could be placed upon these investigations, but only at the expense of other work, or by expansion of research facilities.

There is one further field in which it is felt an all out effort should be made by Malayan producers. Although consumption of dry rubber in America has declined during the past 5 years, the consumption of latex concentrate has remained fairly steady. Consumption of synthetic latex has increased. There is a large outlet for latex in producing foamed rubber goods, an expanding market which must not be lost for natural rubber. New methods of preserving and treating natural latex to keep it in the forefront of foam rubber manufacture must be studied. It is useless, however, to produce a latex preserved with a new and maybe excellent preserving system, unless it can be used by the manufacturer. In general he will not be able to use a latex different from that already employed without modifying his factory processes; and why should he go to that trouble? It is our contention that when a new type of latex is produced, the manufacturer should be presented at the same time with new or modified technological processes to go with it. This

entails much cooperation between the research institutes working in the far east and those in Europe. It requires technological research by our research institutes, it requires advertisement and propaganda by our development units. There is no doubt that given the effort, much progress could be made.

Health Risks from New Insecticides

WITHIN THE LAST DECADE there has been a great development in the use of chemicals for plant protection. Many highly efficient insecticides, fungicides and herbicides are now widely used. Some of them are exceedingly poisonous to man and domestic animals and this prompts the question whether the benefits from their use are sufficient to offset the risk of using them.

In the Malayan rubber planting industry, the most poisonous chemical used at present for weed control is sodium arsenite. However, the potential dangers of this poison are now well appreciated and regulations have been introduced which, when properly complied with, have enabled spraying operations to be undertaken with minimum risk to the personnel engaged, to water supplies and to livestock.

Since the war, however, new synthetic chemicals have been tested for the control of crop pests and weeds and many are now in commercial use. They can be classified roughly into three main groups, namely: (i) nitrated organic compounds, such as the dinitrophenols and cresols; (ii) chlorinated hydrocarbons of which DDT and BHC (Gammexane) are the best known and which also include substances such as toxaphene, chlordane, aldrin and dieldrin; and (iii) the organo phosphorus compounds, the best known being Parathion, TEPP and the systemic insecticides Schradan and Systox. All of these are toxic to mammals in varying degree; most of the organo phosphorus group are exceedingly so.

In addition to replacing the older insecticides, such as the arsenates, nicotine and derris, the new chemicals are being used on an increasing scale to control pests for which there was previously no effective treatment that could be applied economically. They are proving to be valuable weapons for the protection of crops and increasing the world's supply of foodstuffs. Some of these chemicals can be safely used with ordinary care and without the need to take elaborate precautions for the safety of those using them. On the other hand, many have been found to be so dangerous that very great care must be taken when working with them to avoid serious and even fatal poisoning to the operators. Among the latter are many of the organo phosphorus compounds, some of which have recently been imported into Malaya for other agricultural purposes. It is the purpose of this article briefly to review this group of insecticides, to describe the precautions which should be taken during their use and to discuss the effect of these on their possible use under local conditions.

ORGANO PHOSPHORUS INSECTICIDES

Physical properties — Most of these compounds which have been used as insecticides are liquids at ordinary temperatures and are miscible with water, most organic solvents and oils other than kerosine and paraffin oils. A few are solids and others have been made available commercially in solid form *e.g.*, as wettable powders containing 15 to 25 per cent of the pure chemical. They can also be used as emulsions. Some members of the group are fairly rapidly converted by water into less poisonous compounds; but others are less easily decomposed and may remain dangerous even after prolonged contact with water.

Method of application and insecticidal action — The general method of application of these insecticides is by spraying an aqueous solution or emulsion, usually in a dilution of about 1 in 3,000, of the chemical over the crops or vegetation which it is desired to protect from specific pests. Some of the compounds act as contact insecticides, that is to say, the insect must come into physical contact with the insecticide on the surface of the plant in order to be affected. Aphids, mealybugs, scale insects, some caterpillars, leaf miners and red spider are particularly susceptible. Other members of the group, however, appear to be truly systemic in character. They can be absorbed through the roots and become distributed throughout the plant, rendering the whole plant toxic to insects that feed upon it. The latter are usually less toxic to mammals than the contact insecticides, although all are extremely dangerous unless proper precautions are taken when they are handled.

Toxicity to man and other mammals – In addition to being extremely poisonous when taken by mouth, these substances can cause fatal poisoning if they are allowed to come into contact with the skin even in small amounts; while the vapour and dilute sprays are also very dangerous if inhaled or allowed to come into contact with the eyes. It is also possible, though not yet certain, that they can act as cumulative poisons. Recommendations have been made in some countries that agricultural workers who handle these substances should receive regular medical examinations capable of detecting poisoning in its earliest stages. An individual so affected should not be allowed to risk any further contact with the insecticide for a prolonged period.

Two cases are quoted as examples of the hazards that may arise during the use in the field of such sprays or dusts when proper precautions are not taken. A laboratory technician in the United States was applying a 0.05 per cent suspension of one of the more poisonous compounds in a citrus orchard, using a speed sprayer under favourable weather conditions. A few hours after commencing work, he developed a slight headache; four hours later he complained of giddiness and vomitted, and one hour later he died. In another case, a 0.1 per cent wettable powder of the same compound was being applied to a tobacco crop during the morning. At 4.30 p.m. on the same day the operator collapsed, and died a few hours later. It is clear, therefore, that these insecticides should not be handled in agricultural practice except by trained professional workers, who are fully aware of the hazards involved and informed of the precautions necessary to avoid them.

Symptoms of poisoning and treatment — The onset of symptoms of poisoning is insidious. Dangerous amounts of the poison, which may prove fatal if appropriate treatment is not quickly given, may be absorbed before the onset of any warning symptoms. The compounds cause no local irritation when in contact with the skin and the inherent danger of acute poisoning arising therefrom may not be appreciated. The earliest symptoms, which may commence within an hour or two of exposure, include headache, loss of appetite, a feeling of nausea and tightness in the chest. Slight twitching of the muscles of the eye and contracted pupils may also occur. These symptoms may be aggravated by smoking or attempting to eat food. If untreated, more severe symptoms may quickly develop, including difficulty in breathing, vomitting with stomach cramps and diarrhoea, sweating and severe and general muscular spasms. These symptoms rapidly increase in severity, leading to generalised weakness, unconsciousness and finally death which may occur between one and twentyone hours after last exposure to the poison. Partial paralysis of the arms and legs has subsequently developed in some persons who recovered from the acute phase of the poisoning.

The specific antidote for poisoning by the organo phosphorus insecticides is atropine. First aid for such poisoning consists of the immediate removal of the affected person from any risk of further exposure to the poison and complete rest and quiet. A doctor should be called without delay. In the meantime, 0.5 mg (1/120 grain) of atropine (or even double this amount if the symptoms appear to be severe) should be given immediately by mouth. A supply of atropine tablets should always be kept immediately available when any operations involving these insecticides are being undertaken. It is also essential that a careful note be made of the symptoms shown and of any treatment, including the exact amount of atropine, that has been given before the arrival of the doctor, for his information. If at any stage the skin has been contaminated with any of these compounds, whether in concentrated or dilute form, the affected skin surfaces must be washed at once with soap and warm water and the individual should rest, under careful observation, for at least twentyfour hours.

The essence of success is prompt treatment. Even if the person is seen at the earliest stage when only mild symptoms of poisoning are apparent, a rapid transition into more serious stages of poisoning may rapidly occur without further exposure to the poison.

Precautions recommended during the field use of organo phosphorus insecticides — Precautions which have been recommended to safeguard those who handle these insecticides during the preparation of spraying solutions and their use in the field are aimed to prevent any contact of the body with the liquid compounds, their vapour or sprays, however dilute. Certain precautions are obvious such as refraining from smoking or eating when these compounds are being used and the avoidance of splashing when handling the concentrated material. The preparation of spraying solutions should always be carried out in the open air or under conditions of good ventilation. The use of protective clothing and face masks during these operations and when undertaking spraying in the field is recommended; and, in fact, is legally prescribed in the United Kingdom when some of the most poisonous members of

this group are being handled. Such clothing includes a rubberised jacket with high neck and long sleeves tucked into long sleeved gloves; rubberised trousers tucked into gum boots; and for certain operations, the additional wearing of a sou'wester is also required. The face must be protected with a suitable mask to cover the nose and mouth and the eyes are protected with goggles.

Adequate washing facilities must be immediately available in case of accidental contamination and for washing protective clothing, empty containers and spraying equipment after use. Atropine tablets must be readily available always and the operators should work in pairs, never alone. The United States Department of Agriculture has recommended that these insecticides should only be applied with power sprayers or dusters; hand sprayers should never be used.

CONCLUSION

This brief account will indicate the problems that will have to be solved should it be found desirable to use organo phosphorus insecticides to control agricultural pests in Malaya. It is evident that any attempt to enforce the use of the full scale of recommended protective clothing during field operations under the climatic conditions that exist in Malaya would be quite impracticable. No operator would be able to work when almost completely encased in rubber.

Among the questions that will have to be resolved are: firstly, do members of this group of insecticides fulfil a function in the control of local insect pests which cannot be attained almost as effectively or economically by any other less dangerous known insecticide? Secondly, if this is so, are the economic advantages to be gained by the effective control of any particular plant pest sufficiently great as to justify the hazards to health involved? If the answer to the second question is also in the affirmative, the problem will then arise of determining whether and to what extent the severe clothing precautions may be relaxed to enable field work with these insecticides to be undertaken under Malayan conditions without exposing the operators to unjustified health risks.

It is clear that considerable research will be required to answer these questions completely. In the meanwhile, it is evident that a serious risk of fatal accidents will exist should these insecticides be allowed to come into the hands of persons who are ignorant of the dangers involved and unaware of the recommended safety precautions. Recognising this fact, the Government of the Federation has recently introduced legislation to prohibit the import of members of this group of insecticides except under licence by the Director of Medical Services. (Poisons (Dangerous Insecticides) Regulations, 1953. Government Gazette Notification LN 523, September 1953). Control of these insecticides within the Federation is exercised under the provisions of the Poisons Ordinance, No. 29 of 1952, and the Regulations made thereunder. The object of this legislation is to prevent the use of these insecticides by irresponsible persons without, in any way, interfering with research work, undertaken by competent and responsible persons or organisations, and which is necessary to evaluate the possible economic role of these materials and the limitations in their use, under local conditions.

In conclusion, it should be noted that an encouraging feature of the research which is in progress in the development of insecticides based on phosphorus is the discovery of some compounds, such as Malathon, which are far less toxic to warm blooded animals than those at present in commercial use and which yet retain high specific insecticidal properties. Furthermore, there are some non-phosphorus compounds such as Allethrin under investigation, with similar insecticidal properties, which are regarded as having a negligible poison risk. It is therefore possible that in the comparatively near future the control of many agricultural insect pests, which can now only be achieved economically by the use of highly toxic compounds, may be attained by new chemicals far less dangerous to animals and man.

The author is indebted to Mr. H.T. Pagden, Senior Entomologist, Department of Agriculture, Federation of Malaya, for some of the information on which this article has been based; and to Dr T. Wilson, Acting Director, Institute for Medical Research, for useful advice during the preparation of the article.

I.A. SIMPSON

Contributed by the Senior Biochemist of the Institute for Medical Research, Kuala Lumpur.

Tapping Systems

A SHORT HISTORICAL REVIEW of the development of tapping was given in the *Editorial* to our last issue of 1953 (PB 9, page 111). The evolution was traced of the alternate daily system on a half circumference, either V or spiral, from the earliest tapping on multiple cuts and the replacement of the methods of incision by the method of bark excision which, as we noted, originated in Malaya. The operation of tapping was described in some detail in an article in the same issue (page 113); theoretical considerations were discussed and the basis of the international tapping notation was explained.

The ideal tapping system would be one which gives the highest yields at lowest tapping costs with the best growth and bark renewal and the lowest incidence of brown bast. As, however, competition exists between yield and growth a compromise must be sought: there is no universal tapping system that will give the best results on all types of tree and under all conditions. In times of low prices and high wages, yield per tapper takes on a greater significance than yield per acre and consequently tapping systems which give a high yield per unit of labour are of considerable economic interest. The importance of tapping is brought home when it is realised that it is the largest single item in the cost of production of rubber and that it may be as high as 50 per cent of the total cost.

Tapping Systems

In this second article will be described the main tapping systems which are now being used or which have recently been used on estates in Malaya. These systems are:

1 Half circumference alternate daily
2 Full spiral fourth daily
3 Double cut fourth daily (double four)
4 Half circumference third daily
5 Third spiral alternate daily
6 Periodic systems

1. Half Circumference Alternate Daily System C/2.d/2.100% – A system in which the cut extends around half the circumference of the tree and is tapped on alternate days is the most commonly used today on young trees and represents what may well be the best compromise between yield of latex, growth of tree and bark renewal. It is usually the yardstick with which these features in other systems are measured and it is taken as the arbitrary standard (100%) in estimating the relative intensity of tapping systems.

Nearly all clones seem to be able to stand up to continuous alternate daily tapping on a half circumference for many years and provided the trees are well grown and the land is kept in condition by sound methods of soil conservation and by manuring there would seem to be no reason why this system of tapping cannot be maintained for a considerable period. One exception is clone Glenshiel 1 which after a year or so of tapping on this system is liable to develop dry patches on the tapping panel. On the other hand some lower yielding clones, *e.g.* AVROS 256, may do better on a more severe system of tapping.

The half circumference alternate daily system may frequently prove to be too severe for use as a permanent system for clonal seedlings.

It has been customary to bring young budded trees into tapping on panels opened at 40 inches from the union. With a bark consumption of 10 inches a year on half spiral alternate daily tapping this allows 8 years for bark renewal, but where bark consumption is appreciably in excess of 10 inches a year it is not unusual to open all panels at 45 to 50 inches from the union.

Nowadays the first and subsequent panels on budded trees are sometimes opened at the maximum height that an average tapper can work satisfactorily, which may be as high as 50 inches above the union. The decrease in yield with height of tapping on budded trees is small compared with seedling trees and the difference between the heights of 40 and 50 inches above the union is of the order of 8 per cent.

If it is not intended to tap second renewal bark on budded trees, a practice which is favoured on some estates is to open all panels as high as 60 inches above the union and to allow for 24 years' tapping, half of which is on virgin bark and half on first renewal bark.

2. Full Spiral Fourth Daily System S/1.d/4.100% — This system in which the tapping cut extends as a spiral around the full circumference of the trees is of 100 per cent intensity; a full circumference cut tapped every fourth day opens up the same length of cut as a half circumference cut tapped every second day, although on a physiological basis it must be considered to be of greater intensity than the half circumference alternate daily system.

Full spiral cuts tapped daily, alternate daily, and third daily, were used as far back as 1919 in Malaya by A. Sharples and J. Lambourne in studies of brown bast disease but no attempt was made to develop a permanent full spiral tapping system until the publication, by F. Gain in 1935, of the results of the investigations carried out in Malaya by the Socfin Company from 1931 to 1933. The system has since been compared with the half spiral alternate daily system in a series of experiments carried out by the R.R.I.; early results were given in 1941 by R. Scott Russell in Communication 254 of the *Journal of the R.R.I. of Malaya.*

The chief advantage of the full spiral system lies in the reduction of tapping costs, as shown by the following example.

For full spiral tapping a task size of about two thirds of that on half spiral tapping has been found satisfactory and if therefore 390 trees are considered as a fair task on the half circumference alternate daily system, a task of 260 trees can be dealt with on the full spiral fourth daily system. If the yield per tree per annum is the same on both systems one tapper dealing on the full spiral fourth daily system, with a task of 260 trees in four days brings in the yield of 1040 trees; on the half spiral alternate daily system during the same period he would bring in the yield of only 780 trees. If he is paid by the task this represents a saving in tapping cost per pound for full spiral tapping of 25 per cent.

If, as often happens in practice with young rubber, the total yield in full spiral tapping is, at least in the first two years, rather more than on the half spiral alternate daily system, then the saving in tapping cost is still greater. In full spiral tapping the number of tappers required for a given area is reduced by 25 per cent, and there will be concomitant savings in housing and all other incidental labour costs.

There are certain disadvantages of the full spiral fourth daily system. One of immediate importance is the high proportion of low grade rubber, mainly cup lump; because of the late dripping this may be more than twice that recorded in half spiral alternate daily tapping. Another is the possibility of excessive bark consumption owing to the greater extent of drying out at the cut, between tappings.

The most serious drawback of this system is the retarding effect on growth of the trees, particularly budded trees, which is most marked in the youngest and smallest trees, the growth of older and larger trees being less affected. On young budded trees a reduction of potential total yield over the life of the tree due to retardation of growth would be a not unexpected sequel to full spiral tapping, although from the data available this effect would seem to apply with much less force to seedling trees.

We now consider that for full spiral tapping the minimum girth of budded trees should be at least 28 inches at the height of opening and that a girth of 24 inches at the height of opening for tapping seems suitable for seedling trees.

The undesirable features of full spiral tapping may be overcome by introducing periods of rest which, by reducing the intensity of the system, would reduce the yield and ensure a growth rate equal to that obtained when the half circumference alternate daily system is used.

After a long period of tapping on a half circumference, old trees of large size, unless tapped on a V-cut, do not lend themselves readily

to the application of full circumference tapping because of the excessive length of cut which leads to overflow and loss of latex (especially on trees with thin and fluted bark) and the impracticability of extending half spiral cuts without tapping insufficiently renewed bark.

3. Double Cut Fourth Daily System (Double Four) 2S/2.d/4. 100% — This double cut system is a full circumference system which consists in tapping two half circumference cuts one on each side of the tree, preferably separated by a vertical distance of about 20 inches, every fourth day without rest. It originated in Ceylon, from the change over system in common use there, by the simple expedient of tapping on both cuts on the same day. The Sunderland system, in which two half spiral cuts on each tree are tapped every third day for a given period followed by an equal period of rest, originated in the same way.

The object of tapping two cuts on the same tree is to use the tapper's time more economically; the time he spends in walking from tree to tree is halved, thus enabling him to tap more trees and still finish his task in the same time.

The double four system shares with the full spiral fourth daily system the disadvantage of retarded growth (on budded trees) and increased scrap rubber and also, although not quite to the same extent, the advantage of lower tapping cost. It involves two cups and spouts and, all things considered, compares unfavourably with the full spiral fourth daily system.

Clones differ markedly in their response to full circumference tapping; of those sufficiently studied clone Glenshiel 1 is the most adversely affected and clone AVROS 50 the least.

4. Half Circumference Third Daily System C/2.d/3.67% — A system of 67 per cent intensity in which a cut on half circumference, usually a half spiral cut, is tapped every third day without rest. This continuous system is used for certain clones (*e.g.* Glenshiel 1) and seedling families which do not withstand tapping at 100 per cent intensity satisfactorily.

The task size is the same as in half circumference alternate daily tapping but in the third daily system about 50 per cent more trees may be tapped with the same number of tappers than would be used if tapping alternate daily. The DRC of the latex shows an increase of about two percentage units. Bark consumption per tapping is heavier than in the alternate daily system because of the greater drying out at the cut during the interval of three days between tappings; this makes it necessary to take a thicker shaving of bark to obtain a full yield. About 7 to 8 inches per year is consumed.

Eight experiments, mostly on old seedling trees, have shown the average yield from third daily tapping to be 84 per cent of the yield obtained from alternate daily tapping, their relative tapping intensities being as 67 : 100.

In young budded rubber the position is somewhat different as the yield on third daily tapping is on the average about 70 per cent of the yield on alternate daily tapping, or only slightly in excess of the tapping intensity. Tapping costs may be about 15 per cent lower in third daily tapping on seedlings and certain clones.

5. Third Spiral Alternate Daily System S/3.d/2.67% — Another 67 per cent intensity system in which the cut extends around a third of

the circumference of the tree and is tapped on alternate days, this system gives the same yield as the half spiral third daily system, but at a higher cost. The DRC is a little higher than in systems of 100 per cent intensity. Bark consumption is lower than in the third daily system.

In spite of its disadvantages this system is especially useful in clonal seedling areas tapped on the half spiral alternate daily system, where it becomes necessary to tap a proportion of the trees, those with signs of brown bast, at a reduced intensity; it may be more convenient to reduce the length of cut to a third spiral on susceptible trees and maintain the normal alternate daily tapping rotation than to introduce a general system of reduced tapping intensity.

6. *Periodic Systems* — The introduction of periods of rest into the tapping cycle was made originally to reduce tapping intensity on mature trees so that bark consumption did not outstrip bark renewal. The half circumference alternate daily continuous system was found by experience to be too severe for old seedling trees, and the severity of the system was reduced by decreasing the frequency of tapping, as in the half circumference third daily continuous system, or by introducing periods of complete rest, as in the systems formerly designated as A.D., ABC and A.D., ABCD. Some examples of periodic systems are given below.

a C/2.d/2.6m/9.67% – a half circumference cut tapped alternate daily for six months in nine (ABC)

b C/2.d/2.9m/12.75% – a half circumference cut tapped alternate daily for nine months in twelve (ABCD)

c S/2.d/2.12m/15.80% – a half spiral cut tapped alternate daily for twelves months in fifteen (ABCDE)

d S/1.d/4.6m/8.75% – a full circumference cut tapped fourth daily for six months in eight (ABCD).

In the 67 per cent intensity system *a* there are three-monthly rotational rests on ABC, *i.e.* the area is divided into three sections and at three-monthly intervals a rested section is brought into tapping and a tapped section is taken into rest.

In the 75 per cent intensity systems *b* and *d* the area is divided into four sections; at three-monthly intervals in *b* and at two-monthly intervals in *d* rested section is brought into tapping and a tapped section is taken into rest.

In the 80 per cent intensity system *c* the area is divided into five sections and at three-monthly intervals a rested section is brought into tapping and a tapped section is taken into rest.

In periodic systems on low yielding trees the yield per tapping, during the periods of tapping, is higher than it would be in continuous tapping; tapping cost will vary inversely with yield per tapping, the higher the increase in yield per acre tapped the greater will be the saving in tapping costs. In young high yielding areas which show no effect of resting periods on yield, tapping costs remain unaffected.

The belief that the half circumference alternate daily periodic (ABC) systems of 67 per cent intensity, introduced by Mr C.R. Harrison in 1927, would eventually give yields equal to those obtained in half circumference alternate daily continuous tapping may be realised only in areas of old seedling rubber yielding on the average not much more than 400 lb per acre per year.

Tapping Systems

In a survey of the yields recorded in old seedling areas of estates on changing over from alternate daily continuous to alternate daily periodic (ABC) tapping it was found that areas yielding on an average 400 lb per acre on half circumference alternate daily tapping would yield on the periodic (ABC) system about 90 per cent during the first three years, whereas areas capable of an average yield of 675 lb per acre when tapped alternate daily on a half circumference only yielded 72 per cent of that yield on periodic ABC tapping during the same period.

From this survey it became clear that a yield over the first three years of over 80 per cent of the yield on the half circumference alternate daily system would not be obtained from areas capable of yielding more than 500 to 600 lb per acre on that system.

In an R.R.I. experiment carried out by the late Mr C.C.T. Sharp at Seventh Mile Estate from 1933 to 1938 on unselected seedling trees, planted in 1911 and yielding about 850 lb per acre per year on the half circumference alternate daily system, three types of the alternate daily periodic (ABC) system with periods of tapping and of rest of 6 and 3, 10 and 5, 14 and 7 months respectively were compared over a period of five years. It was found that the yields as a percentage of the control system (C/2.d/2.100%) were 83, 81 and 77 for the three ABC treatments with 3, 5 and 7 months' rest respectively. Under the conditions of the experiment the optimum rest period was about 3 months; the loss in yield was progressively increased when the rest was extended beyond that period due to the reduction in the number of flush crops after rest.

ABC tapping with periods of six months' tapping and three months' rest generally results in a higher yield per acre than longer periods such at twelve months' tapping and six months' rest, though the latter may give better bark renewal on old low yielding seedling trees.

On high yielding budded trees the mean relative yield over the first six years of alternate daily periodic (ABC) systems is on the average about 70 per cent of that of alternate daily continuous tapping or only very little more than the proportional reduction in tapping intensity. The loss in crop is therefore of the order of 30 per cent whether the trees are tapped A.D., ABC or third daily.

A disadvantage of the periodic system is the fluctuation in the dry rubber content of the latex which is very high immediately after a resting period and falls rapidly during the first few weeks of tapping. The average dry rubber content over a long period is, however, little different from that on continuous alternate daily tapping and is about 2 percentage units lower than that on the continuous third daily system.

Bark consumption is higher but tapping costs are lower in the continuous third daily system than on the alternate daily periodic (ABC) system.

Periodic (ABCD) systems lengthen the period of tapping relative to the period of rest and are of higher intensity than ABC systems, with 135 tapping days in a full tapping year compared with 120 tapping days in the ABC systems.

BOTANICAL DIVISION

Testing Latex Concentrates

THE R.R.I. PROVIDES analytical and testing services to latex producers. For a small fee the manufacturer is able to get authoritative information on the quality of his product, and by this means is often able to avoid production troubles. Users of the service may find it of value to learn how the R.R.I. does test their samples.

Most of the tests used are internationally accepted standard methods, so that manufacturers may safely compare R.R.I. figures with those supplied by any laboratory in the world using similar standards. Alterations to these methods are only made by agreement after exhaustive checks have shown that a useful improvement can be got. The R.R.I. is in the forefront of scientific research on testing methods and has recently developed a new method (the VFA test) which gives quantitative information never before available on the state of degradation of a latex sample. Details were published in February of last year in our *Journal* and the test is already available as an additional routine service in Malaya. In other countries it is being tried out, and it may one day be the basis of a new agreed standard. Meanwhile, some description of its operation and implications is included below.

The tests which are commonly made on latex concentrate, including the new VFA test, are as follows.

Dry rubber content (percentage by weight) — The d.r.c. or dry rubber content represents the weight in grams of rubber actually present in 100 grams of the latex sample. A standard amount of latex is weighed out on a sensitive balance. The latex is coagulated with acetic acid under exactly standard conditions; the coagulum is washed, pressed and dried before weighing again.

Total solids (percentage by weight) — Since d.r.c. is a measure of the rubber content of the sample, it takes no account of the non-rubber constituents which are always present, and which have an important influence on the properties of the latex. It is therefore necessary to find the total solid content by evaporating a weighed amount of latex, under standard controlled conditions, and weighing the product. The results are expressed in the same form as the d.r.c. The difference between this result and the d.r.c. gives approximately the weight of non-rubber substance present, which in a normal concentrate of 60% d.r.c. varies between 1.6 and 2.0%.

Ammonia (by weight) – We recommend that the minimum quantity of ammonia for satisfactory preservation of latex should be 0.7% of the whole weight of the latex. This is slightly higher than the 0.64% specified by the American Society for Testing Materials, because we have found the small extra margin of safety to be essential in practice. Our results are always expressed as a percentage of the whole latex, but if required they can be converted to a percentage of the water phase by multiplying them by the factor $\frac{100}{100 - \text{t.s.}}$

pH — This gives a numerical estimate of the alkalinity of the latex. A neutral solution has a pH of 7.0, figures above this represent alkalinity. A solution with a pH below 7 would be acid. Latex preserved with 0.70 per cent ammonia has a pH of about 10.5.

KOH number — When caustic potash is added to latex a number of chemical reactions take place as a result of which potassium salts of the fatty acids present are formed, whilst combined ammonia is expelled. The amount of caustic potash (KOH) required under standard conditions (grams KOH per 100 grams total latex solids), is called the KOH number and has been taken as a measure of the degradation of the latex since fatty acids are associated with the process of degradation. There are, however, many essential points which must be borne in mind when operating the test or interpreting its results.

First of all any surplus of free ammonia in the sample must be reduced if the results are to signify. This is done by a preliminary titration with formalin, after which the caustic potash is added and allowed to react. There is usually present such a mixture of different organic acids in various states of combination, that it is difficult to say at what point the reaction should be regarded as complete for this purpose. Some of these acids reduce the stability of the latex; others have exactly the reverse effect. A distinction between the two types cannot be made by the KOH number test. As the caustic potash is added to the mixture the pH (measured electrically) rises. In practice it is found most useful to stop the addition when the pH of the mixture begins to climb above 11.0, and report the amount added as the KOH number.

This is often taken as a measure of acid content, but it must be pointed out that it does not measure the entire acid content, moreover it gives no information as to whether the acids are detrimental or not. The KOH number therefore has no absolute significance. Nevertheless until the advent of the VFA test it was the best that could be done, and a very high KOH number usually means a badly degraded latex.

Volatile fatty acid content – This test became a practical possibilty after research had shown that the naturally occurring acids causing instability in latex are more volatile than those which act as stabilisers. It is thus possible to distil off the destabilising acids, and to collect and estimate them directly and positively.

The distillation must be done under standard conditions in a specially designed still, and it is only recently that a suitable procedure has been established. It is now possible to estimate the VFA content with satisfactory precision, the result being expressed as grams caustic potash required to neutralise the VFA content of a latex sample containing 100 grams total solids.

An exceptionally well preserved latex may have a VFA number as low as 0.03. Values much in excess of 0.10 indicate an appreciably degraded and inferior product.

Mechanical stability — Latex coagulates if agitated too much. The mechanical stability test measures quantitatively how much agitation is needed to bring this about. Clearly strict standardisation of method is needed if the results of different laboratories are to be comparable. Both the A.S.T.M. (American Society for Testing Materials) and the B.S.I. (British Standards Institution) have dealt with this problem and have issued standard methods which differ only in details. Both methods rely on stirring the latex (at specified temperature and concentration) at exactly 14,000 r.p.m. in a specially designed machine, until a recognised degree of flocculation appears. The R.R.I. of Malaya normally uses the

A.S.T.M. version of the test. It is expected that in the near future American and British standards will agree upon the details of the test.

Odour of latex — The process of degradation of latex announces itself to the nose when it reaches a certain stage. To carry out the test under the best conditions, it is first necessary to remove any smell of ammonia by neutralisation with acid (boric or sulphuric). Then the extent of decomposition is judged. It is a test of value as a supplement to the KOH number test, or where no other test is available, but it is of course subjective and it is not sensitive to the early stages of putrefaction.

These, then, are the tests which we normally apply to latex. How are they to be interpreted? Is your latex up to standard or not? The answer of course depends on how it is to be used, but we give below for your information the A.S.T.M. specifications published in 1953 for centrifuged and creamed latex. The VFA test is not included in these. Unless especially requested, we do not test for sludge, copper, manganese, viscosity or coagulum content, but of course facilities are available for these tests if they are required.

TABLE I: A.S.T.M. SPECIFICATIONS FOR LATEX CONCENTRATES

Property	*Type I centrifuged*	*Type II creamed*
Total solids (t.s.), min. %	61.5	64.0
Dry rubber content (d.r.c.), min. %	60.0	62.0
(t.s. – d.r.c) max. %	2.0	2.0
Total alkalinity as ammonia on water phase in latex, min. %	1.6	1.6
KOH number, max.	0.80	0.80
Mechanical stability, min. (sec)	400	400
Sludge (% of wet weight), max.	0.10	0.10
Copper content max. (% t.s.)	0.0010	0.0010
Manganese, max. (% t.s.)	0.0010	0.0010
Odour after neutralising with boric acid	*No putrefactive odour*	
Coagulum content max. % of total solids	0.080	0.080
Viscosity, limiting coefficient at 25°C, max. (centipoises)	50	50
Colour on visual inspection	*no pronounced blue or gray*	

The requirement on mechanical stability is provisional until more data from the test at 55% total solids have been accumulated. The previous specification for the mechanical stability test was 600 seconds at 51.5%t.s. and this is still in use at the R.R.I. until such time as the new specification is adopted by the industry.

CHEMICAL DIVISION

Stinking Root Rot

ITS NAME AND STRIKING APPEARANCE have given this disease an exaggerated reputation as an enemy of the rubber tree. It is sometimes regarded as on a par with white or red root disease, whereas our advisory files record not a single postwar case. It is so readily recognised and occurs under such clearly defined conditions that our readers need have no doubt in identifying it. If those who come across it will let us know, we shall be better able to assess its importance over the country as a whole.

Figure 1. Part of a root from which the bark has been stripped, showing the pattern of the rhizomorphs.

The name gives a clue to where the disease occurs—in wet low lying areas. The 'stink' is not produced by the root disease fungus itself (*Sphaerostilbe repens*) but arises from decomposition brought about by the numerous fungi and bacteria which thrive in such wet conditions. The smell may be sufficiently strong to be discernible when walking through affected fields.

Sphaerostilbe, like the three major root parasites, has characteristic rhizomorphs by which it can be recognised: it is unlike them in that the rhizomorphs do not appear on the surface of the root. When the bark is stripped the pattern of the rhizomorphs is seen on the underside and on the wood (*Figure 1*). The rhizomorphs themselves are black strands radiating outwards from centres on the surface of the wood.

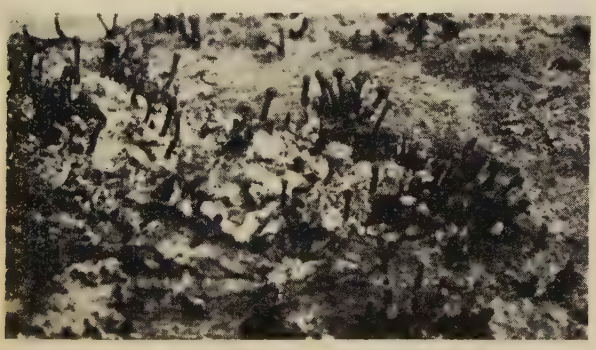

Figure 2. Fructifications on the surface of a root (natural size).

The fructifications are completely different from the other root parasites. The spore bearing bodies are

the size of a pin's head, stalked, emerging from the surface of the root as shown in *Figure 2*. Spores can readily establish a new infection, unlike those of the major root parasites which do not infect intact trees.

One of the few cases of *Sphaerostilbe* we have encountered since the war was on a very young seedling growing in a pot in the laboratory. It had been kept under a bell jar in continuously wet soil for two weeks before it wilted and died, and the collar became covered with fructifications producing spores which readily grew on an agar medium, even producing new fructifications and rhizomorphs running down into the agar.

Although an infection originates from spores, the rhizomorphs are responsible for spreading the fungus over the root system. Records from before the war show that it has even been found invading living wood above ground level. The effect of the growth of a parasite throughout the root system of the tree is inevitably the same for all the root disease fungi—drooping and yellowing of the leaves with eventual death of the tree. *Sphaerostilbe repens*, however, is a feeble parasite which cannot develop on healthy plants growing in well drained soil.

PATHOLOGICAL DIVISION

Correspondence

The Editor of PLANTERS' BULLETIN *invites letters of general interest for publication in this column. Comment and queries arising from articles recently published will be welcome. The name and address of the writer must be given in full, but may be withheld from publication if desirable.*

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PB 86 AS A SEED PARENT

In *Planters' Bulletin 5* (page 42) you published the information you had then collected regarding the performance of PB 86 as a seed parent. From inquiries we have received it appears that your article has had read into it considerable condemnation of PB 86 as a seed parent.

During 1928 to 1932 the late Dr Chittenden carried out breeding work by hand pollination with Prang Besar clones and the legitimate seedlings were planted in five plots at a low stand per acre, which made thinning out unnecessary. All seeds which germinated were planted and there was no elimination from the basket nurseries of plants which might be thought genetically weak. Thus all possible steps were taken to obtain a true picture of the breeding value of the parental clones. The total number of families in these five plots was 39 and PB 86 was one parent in 9 of these. The results of the first 29 months of experimental tapping of the seedlings in each family, on the s/2.d/2. 100% system, may be summarised:

Prang Besar Plots
P1 (1928), P2 (1929),
P3 (1930), P4 (1931),
P5 (1932).

Mean yields in lb/acre

A (all 39 families)	1920.6
B (all 30 families excluding PB 86 crossings)	1923.8
C (all 9 families of PB 86 crossings)	1910.3
C as a percentage of *A* :	99.4
C as a percentage of *B* :	99.3

These results show that the mean yield of families with clone PB 86 as one parent (9 crossings in 7 combinations) is on the average no different from that of 30 other crosses in 28 combinations between early Prang Besar clones which are represented in Prang Besar Isolation Seed Gardens C,D and E, the seed from which is approved by the R.R.I. for commercial planting.

A further five plots similar to those laid down in 1928 to 1932 were laid down between 1934 and 1937 and the yield of the families of which one of the parents is PB 86, expressed as a percentage of the average yield for all families in each plot, was as follows:

Prang Besar Plots

P7 (1934-5), P8 (early 1936), P9 (1936-7) and P10 (1937) tapped January to December 1949.

Mean yield of PB 86 crossings as a percentage of mean yield from each plot

P7	11 families (2*)	98%
P8	4 families (2)	99%
P9A	4 families (2)	105%
P9B	4 families (1)	102%
P10A	9 families (2)	114%

* *in parentheses appear the numbers of the families having PB 86 as a parent.*

Here again the mean yield of the seedling families which have clone PB 86 as one parent is not inferior to the mean yield of all seedling families in the various plots. The families planted in the ten plots were not subjected to a statistical layout and the families are of unequal size. For these reasons the figures given may be subject to factors which cannot be estimated, but these factors, however, may be largely discounted by the smallness of the total area involved and by the close proximity of the plots to each other.

The results of the above two trials have subsequently been confirmed by the results from a further area planted in 1935 with individual sorted clonal seed from the Company's Isolation Gardens which include clone PB 86.

Test tapping over fourteen months showed that:

a the yield of PB 86 seed as a percentage of the yield of all types is 99%;

b the average yield of the PB 86 seed as a percentage of the remaining types is 99%.

We suggest that clone PB 86 as a seed parent has much better qualities than appear to be the general impression as a result of your article of March 1953.

Harrisons & Crosfield (M) Ltd
Agents, Prang Besar
Rubber Estates Ltd.

The data from the Prang Besar plots provide a comparison between the progenies of Prang Besar clones which are represented in the Prang Besar Isolation Gardens C, D & E and a better appraisal of the value of the clones as seed parents would be obtained by comparing yields of the individual seedling families.

It may be concluded, however, that the presence of clone PB 86 in the various plots has not detracted from the value of the seed as planting material since the average yield of the seedling families with PB 86 as one parent

is very close to the average yield for each plot.

In the last example cited, sorted seed of clone PB 86 from P.B.I.G. plot C have given approximately the same yield as the mixed seed of all the clones represented in the plot and the Prang Besar data, as a whole, indicate that the yield of the seedling families which have clone PB 86 as one parent are in no way inferior to those of the mixed seed from the same plots.

Good yields have been obtained from illegitimate seedlings of clone PB 86 in commercial plantings as seen from the following examples.

An area of 65 acres planted in 1937 with sorted seed of clone PB 86 collected from a mixed budded area of clones PB 23, 86, 183 and SR 9 and tapped on the half spiral alternate daily system yielded during the period 1948 to 1952 an average of 1100 lb per acre per year.

Sorted seed of clone PB 86 from an isolation seed garden containing 21 clones, amongst which were clones Tjir 1, AVROS 157, 163, Pil B84 and Lun N, have given yields as good as those of Tjir 1 seed from the same garden.

The mean yields in pounds per acre per year over a period of seven years – 1947 to 1953 – of seedlings planted in 1938 were as follows.

Family	*Est. A*	*Est. B*	*Est. C*
PB 86 illeg.	*1146*	*1208*	*815*
Tjir 1 „	*1042*	*1189*	*881*

These results from three estates indicate that from the progeny of this seed garden – where the layout provides for unrestricted cross pollination between 21 clones, and the proportion of 'selfs' may be very small – seedlings of PB 86 parentage are about equal to those of Tjirandji 1 parentage.

Little is known of the value of the selfed seed of clone PB 86 and the seed is not recommended for planting on other than an experimental scale.

The illegitimate seedlings of PB 86 used in the R.R.I. clonal seedling trials on estates (Table XXII in 'Report for years 1949-51 of the Botanical Division of the Rubber Research Institute of Malaya') which have yielded 10 to 20% less than selfed seedlings of Tjir 1 were obtained from monoclone plantings of clone PB 86 and would be expected to be mainly 'selfed' seedlings.

The results from practice, as quoted above and supported by other data we have received and hope to publish shortly, indicate that the progeny of clone PB 86 may sometimes be quite satisfactory and equal in value to that of the seedling families derived from other clones.

R. R. I. News

A fire in the new latex laboratories at the R.R.I. Experiment Station has set back work on the non-rubber constituents of latex, owing to the loss of a high speed centrifuge.

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A slaughter tapping experiment with systems of 150, 200 and 300 per cent intensity, with and without the application of a yield stimulant, was laid down on a collaborating estate during the quarter in an area representative of the old seedling plantings in Malaya.

Courses for Senior Estate Conductors

The pre-war arrangement of revision courses at the R.R.I. Experiment Station is resumed; training courses are offered this year during 5 to 10 April, and 14 to 19 June. The programme will be mainly on field work. Demonstrations, talks and lectures will include replanting and new planting procedures, weed control, establishment of leguminous covers, budgrafting and hand pollination, pests and disease treatments, fertiliser application, yield and bark stimulants, tapping systems and slaughter tapping. A maximum of eight conductors can be taken for each course. They must be senior experienced men who are actually in employment, and all applications must be made by the manager of the estate concerned. Full details will be provided on application to the Director.

R. R. I. Lectures to Planters

The following lectures are available during 1954. Inquiry may be made of the Director.

SOILS DIVISION

C.G. AKHURST: *Weed control*

G. OWEN: *Soils and the nutrition of the rubber tree*

BOTANICAL DIVISION

E.D.C. BAPTIST: *Problems of current interest on estates* or *Improvement of yield in hevea*

H.M. BURKILL (until August): *Clones and clonal seedlings*

C.W. BROOKSON: *Plant breeding and testing*

P. DE JONGE (after June): *Yield stimulation*

PATHOLOGICAL DIVISION

A. NEWSAM: *Recognition of pests* or *Termites and borers*

F.W. HUTCHISON: *Root diseases* or *Spraying from the air*

R.N. HILTON: *Windborne diseases*

CHEMICAL DIVISION

L.L. BEST or P.F. MAHER: *Methods of technical classification in Malaya*

A.S. COOK: *Sheet, crepe and latex production*

H.M. EDMONDSON (after April): *Cyclised rubber manufacture*

OUR COVER ILLUSTRATION SHOWS A KLAXON MECHANICAL STABILITY TESTER FOR LATEX, MODIFIED FOR USE IN THE R. R. I.

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